F2-04AD-2, F2-04AD-2L 4-Channel Analog Voltage Input

3

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- Module Specifications
- Setting the Module Jumpers
- Connecting the Field Wiring
- Module Operation
- Writing the Control Program

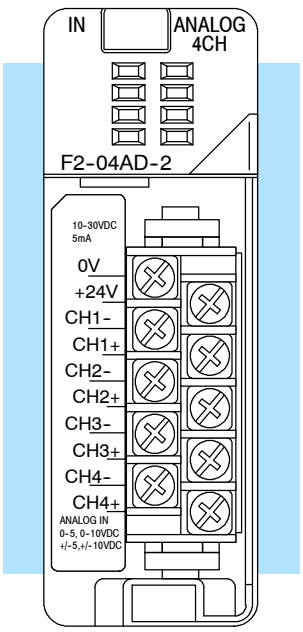
Module Specifications

F2-04AD-2

The F2-04AD-2 analog Input module provides several hardware features.

- Analog inputs are optically isolated from the PLC logic.
- The module has a removable terminal block so the module can be easily removed or changed without disconnecting the wiring.
- With a DL240/250-1/260 CPU, you can read all four channels in one scan.
- On-board active analog filtering and microcontroller provide digital signal processing to maintain precision analog measurements in noisy environments.

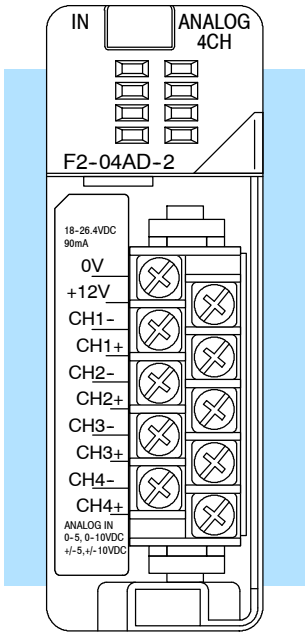
F2-04AD-2



F2-04AD-2L (Obsolete)

NOTE: *In 2009 the F2-04AD-2L was discontinued. A re-designed F2-04AD-2 was released at the same time which can be powered by either 12 VDC or 24VDC input power supplies. This new module is a direct replacement for prior F2-04AD-2 and all F2-04AD-2L modules. The new module is a single circuit board design and the jumper link locations are different. See Setting the Module Jumpers on page 3-5. Also, some specifications were changed on page 3-3. Otherwise, the re-designed module functions the same as the prior designs.*

F2-04AD-2L



All specifications are the same for both modules except for the input voltage requirements. Review these specifications to make sure the module meets your application requirements.

Input Specifications

Number of Channels	4, single ended (one common)
Input Ranges	0 to 5V, 0 to 10V, ±5V, ±10V
Resolution	12 bit (1 in 4096) unipolar (0 - 4095) 13 bit (1 in 8192) bipolar (-4095 - +4095)
Common Mode Rejection	-50 dB at 800 Hz
Step Response	8.2 ms (*10 ms) to 95% of full step change
Crosstalk	-70 dB, 1 count maximum
Active Low-pass Filtering	-3 dB at 80Hz, 2 poles (-12 dB per octave)
Input Impedance	> 20 MΩ
Absolute Maximum Ratings	-75 to +75 VDC
Converter type	Successive approximation
Linearity Error (End to End)	±1 count (0.025% of span) maximum unipolar ±2 counts maximum bipolar
Input Stability	±1 count
Full Scale Calibration Error (Offset error not included)	±3 counts maximum
Offset Calibration Error	±1 count maximum (0V input)
Maximum Inaccuracy	±.1% @ 25°C (77°F) ±.3% 0 to 60°C (32 to 140°F)
Accuracy vs. Temperature	±50 ppm / °C full scale calibration change (including maximum offset change of 2 counts)

One count in the specification table is equal to one least significant bit of the analog data value (1 in 4096).

General Specifications

PLC Update Rate	1 channel per scan maximum (D2-230 CPU) 4 channels per scan max. (D2-240/250-1/260CPU)
Digital Inputs Input points required	12 binary data bits, 2 channel ID bits, 1 sign/diagnostics bit, 1 diagnostic bit 16 point (X) input module
Power Budget Requirement	110 mA (*60 mA) maximum, 5 VDC (supplied by base)
External Power Supply	5 mA (*90 mA) max., 10-30 VDC (*18-26.4 VDC) (F2-04AD-2 models); 90 mA maximum, 10 to 15 VDC (F2-04AD-2L models)
Operating Temperature	0 to 60° C (32 to 140° F)
Storage Temperature	-20 to 70° C (-4 to 158° F)
Relative Humidity	5 to 95% (non-condensing)
Environmental air	No corrosive gases permitted
Vibration	MIL STD 810C 514.2
Shock	MIL STD 810C 516.2
Noise Immunity	NEMA ICS3-304

*Values in parenthesis with an asterisk are for older modules with two circuit board design and date codes 0609F4 and previous. Values not in parenthesis are for single circuit board models with date code 0709G and above.

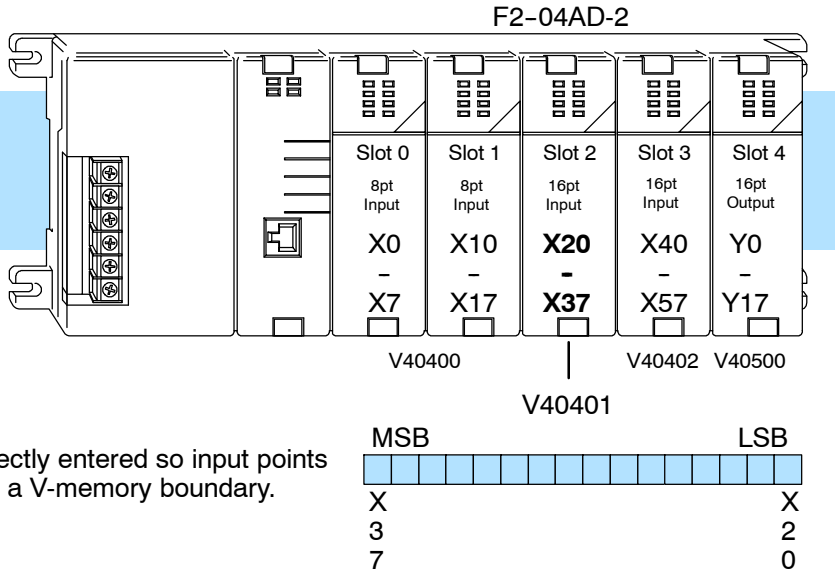
Analog Input Configuration Requirements

Appears as a 16-point discrete input module and can be installed in any slot of a DL205 system. The available power budget and discrete I/O points are the limiting factors. Check the user manual for your particular model of CPU and I/O base for more information regarding power budget and number of local, local expansion or remote I/O points.

Special Placement Requirements (DL230 and Remote I/O Bases)

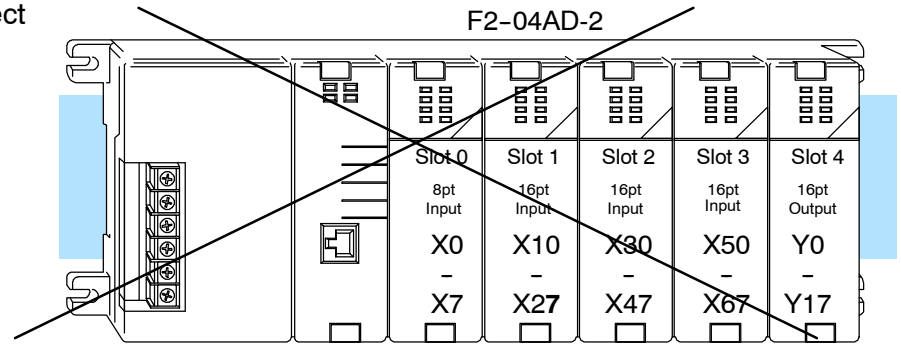
Even though the module can be placed in any slot, it is important to examine the configuration if you are using a DL230 CPU. As you can see in the section on writing the program, you use V-memory locations to extract the analog data. If you place the module so that the input points do not start on a V-memory boundary, the instructions cannot access the data. This also applies when placing this module in a remote base using a D2-RSSS in the CPU slot.

Correct!

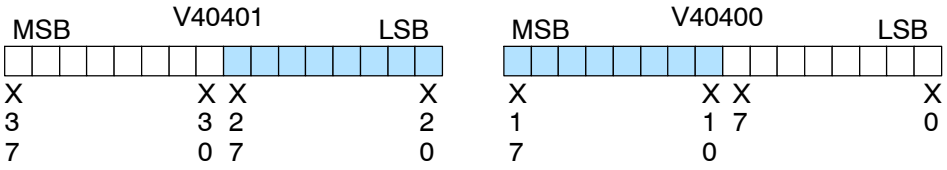


Data is correctly entered so input points start on a V-memory boundary.

Incorrect



Data is split over two locations, so instructions cannot access data from a DL230.



To use the V-memory references required for a DL230 CPU, the *first* input address assigned to the module must be one of the following X locations. The table also shows the V-memory addresses that correspond to these X locations.

X	X0	X20	X40	X60	X100	X120	X140	X160
V	V40400	V40401	V40402	V40403	V40404	V40405	V40406	V40407

Setting the Module Jumpers

Selecting the Number of Channels

There are two jumpers, labeled +1 and +2, that are used to select the number of channels that will be used. See the figures below to find the jumpers on your module. The module is set from the factory for four channel operation.

Any unused channels are not processed, so if you only select channels 1 thru 3, channel 4 will not be active. The following table shows how to use the jumpers to select the number of channels.

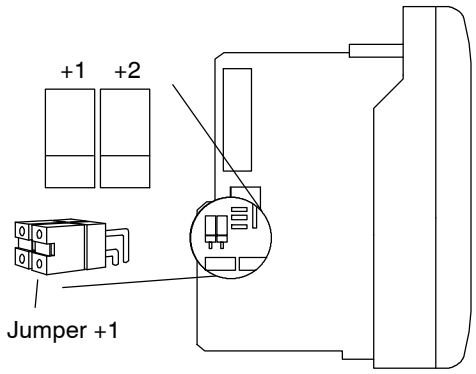
Channel	+1	+2
1	No	No
1, 2	Yes	No
1, 2, 3	No	Yes
1, 2, 3, 4	Yes	Yes

Yes = jumper installed

No = jumper removed

For example, to select all 4 channels (1–4), leave both jumpers installed. To select channel 1, remove both jumpers.

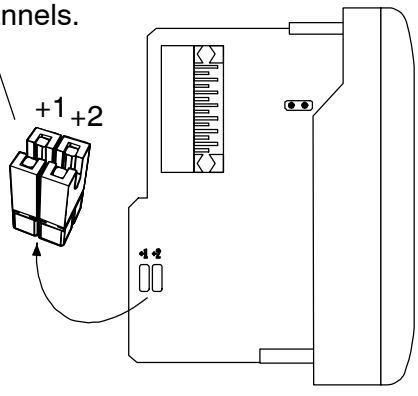
Jumper Location on Modules Having Date Code 0609F4 and Previous (Two Circuit Board Design)



These jumpers are located on the motherboard, the one *with* the black D-shell style backplane connector.

Jumper Location on Modules Having Date Code 0709G and Above (Single Circuit Board Design)

Use jumpers +1 and +2 to select number of channels.



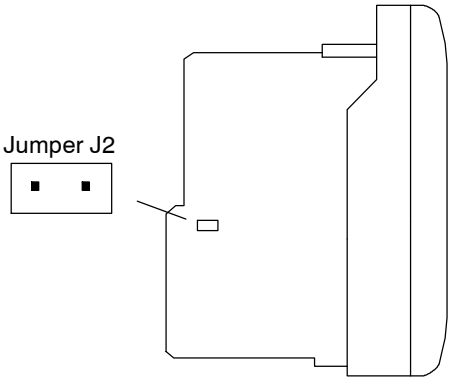
Selecting the Input Signal Range

There is another jumper, labeled either J2 or J3 (depending on the whether you have a single or double circuit board module), that is used to select between the 5V ranges and the 10V ranges. See the figures below to locate the jumper on your module. The module comes from the factory set for 10V operation (jumper not installed).

Install jumper J2 or J3 for 0–5V or ±5V operation.

Remove J2 or J3, or store on a single pin, for 0 to10 or ±10V operation.

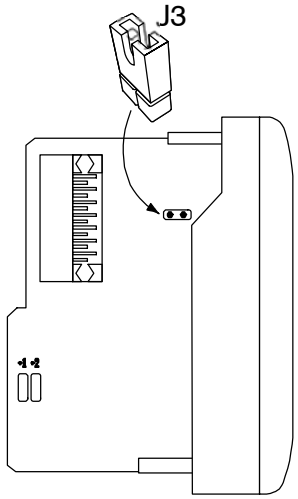
Jumper J2 Location on Modules Having Date Code 0609F4 and Previous (Two Circuit Board Design)



Jumper J2 is located on the smaller circuit board, which is on top of the motherboard.

Install J2 for 0–5V or ±5V operation. Remove J2, or store on a single pin, for 0 to10 or ±10V operation.

Jumper J3 Location on Modules Having Date Code 0709G and Above (Single Circuit Board Design)



Install J3 for 0–5V or ±5V operation. Remove J3, or store on a single pin, for 0 to10 or ±10V operation.

Connecting the Field Wiring

Wiring Guidelines

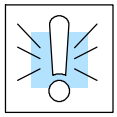
Your company may have guidelines for wiring and cable installation. If so, you should check those before you begin the installation. Here are some general things to consider:

- Use the shortest wiring route whenever possible.
- Use shielded wiring and ground the shield at the transmitter source. *Do not* ground the shield at both the module and the source.
- Do not run the signal wiring next to large motors, high current switches, or transformers. This may cause noise problems.
- Route the wiring through an approved cable housing to minimize the risk of accidental damage. Check local and national codes to choose the correct method for your application.

User Power Supply Requirements

The module requires at least one field-side power supply. You may use the same or separate power sources for the module supply and the voltage transmitter supply. The F2-04AD-2 module requires 18–26.4VDC at 80 mA. The DL205 bases have built-in 24 VDC power supplies that provide up to 300mA of current. You may use this instead of a separate supply if you are using only a couple of analog modules.

It is desirable in some situations to power the transmitters separately in a location remote from the PLC. This will work as long as the transmitter supply meets the voltage and current requirements, and the transmitter minus (–) side and the module supply's minus (–) side are connected together.



WARNING: If you are using the 24 VDC base power supply, make sure you calculate the power budget. Exceeding the power budget can cause unpredictable system operation that can lead to a risk of personal injury or damage to equipment.

The DL205 base has a switching type power supply. As a result of switching noise, you may notice ±3–5 counts of instability in the analog input data if you use the base power supply. If this is unacceptable, you should try one of the following:

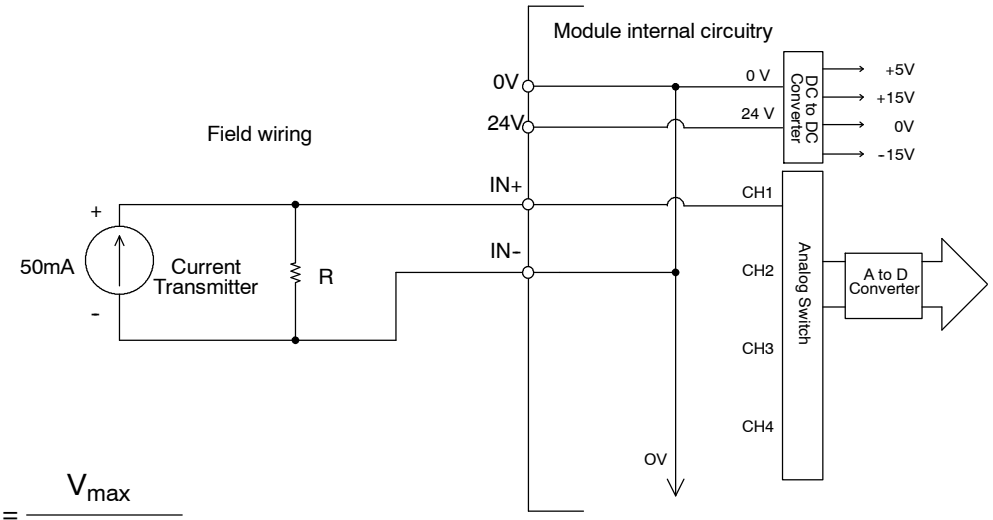
1. Use a separate linear power supply.
2. Connect the 24VDC common to the frame ground, which is the screw terminal marked "G" on the base.

By using these methods, the input stability is rated at ±1 count.

The F2-04AD-2L requires 10–15VDC at 90mA and must be powered by a separate power supply.

Custom Input Ranges

Occasionally you may have the need to connect a (current) transmitter with an unusual signal range. By changing the wiring slightly and adding an external resistor to convert the current to voltage, you can easily adapt this module to meet the specifications for a transmitter that does not adhere to one of the standard input ranges. The following diagram shows how this works. The example below only shows channel 1, but you can also use the other channels as well.



$$R = \frac{V_{max}}{I_{max}}$$

R = value of external resistor

V_{max} = high limit of selected voltage range (5V or 10V)

I_{max} = maximum current supplied by the transmitter

Example: current transmitter capable of 50mA, 0 – 10V range selected.

$$R = \frac{10V}{50mA} \qquad R = 200 \text{ ohms}$$

NOTE: Your choice of resistor can affect the accuracy of the module. A resistor that has ±0.1% tolerance and a ±50ppm / °C temperature coefficient is recommended.

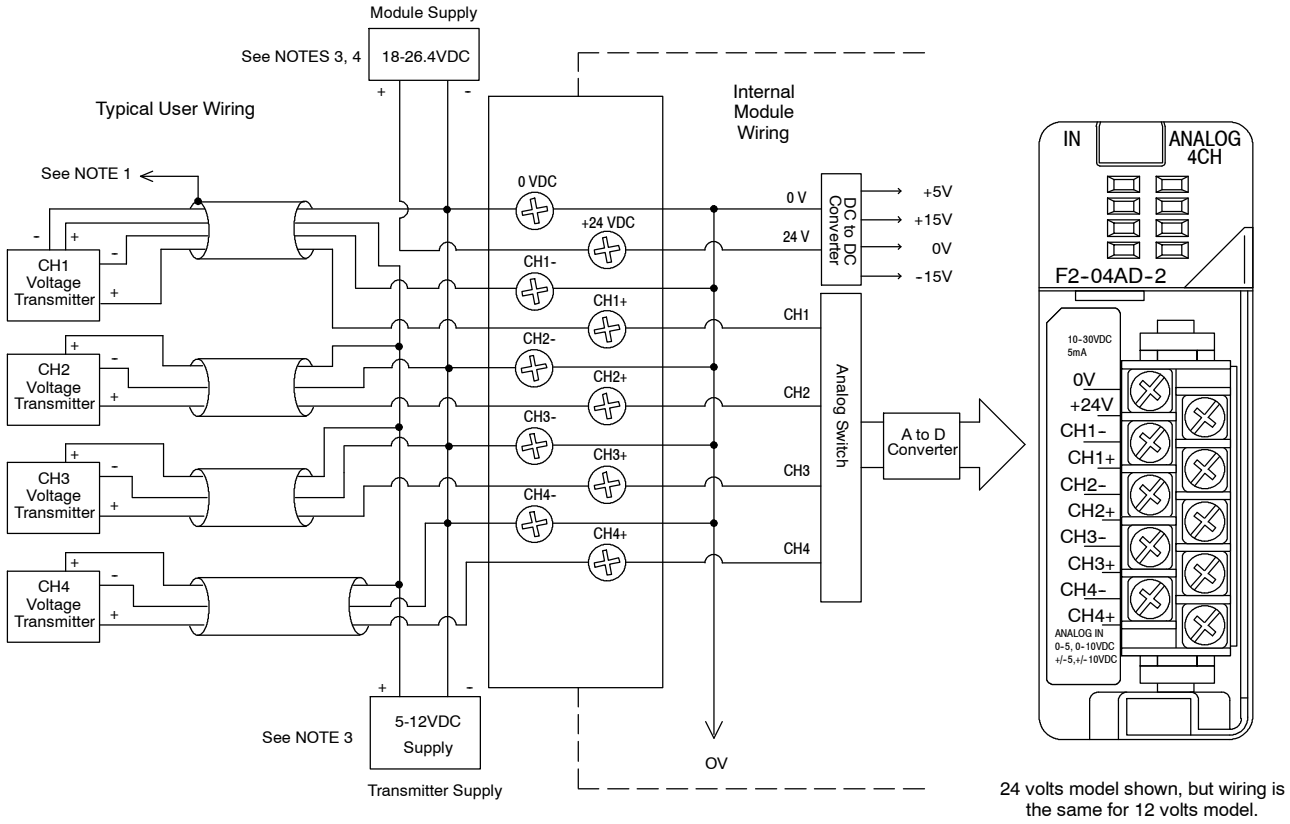
If you use 4–20mA signals and convert them to voltage using this method, you can easily check for broken transmitter conditions. For example, if you are using the 0–5V range and the lowest signal for the 4–20mA transmitter is 4mA, the lowest digital value for the signal is not 0, but instead is 819.

If the transmitter is working properly, the smallest value would be 819 in the DL205. If you see a value of less than about 750 (allowing for tolerance), then you know the transmitter is broken.

Wiring Diagram

The module has a removable connector to make wiring easier. Simply squeeze the top and bottom retaining clips and gently pull the connector from the module. Use the following diagram to connect the field wiring. The diagram shows separate module and transmitter power supplies. If you desire to use only one field-side supply, just combine the supplies' positive (+) terminals into one node and remove the transmitter supply.

Notes: 1. Shields should be grounded at the signal source.
2. Unused inputs should be jumpered together (i.e. Ch4– to Ch4+).
3. More than one external power supply can be used provided the commons are connected together.
4. F2-04AD-2L requires 10–15 VDC input supply.



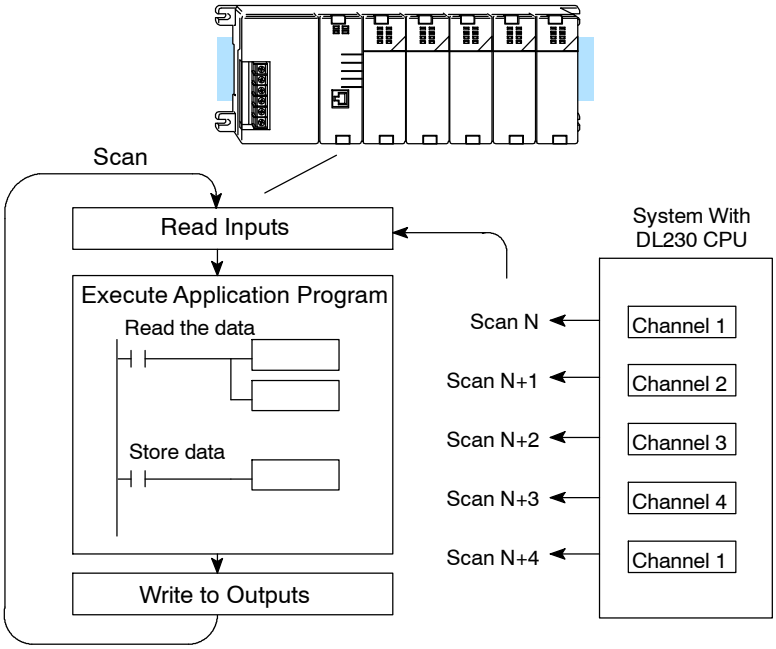
24 volts model shown, but wiring is the same for 12 volts model.

Module Operation

Before you begin writing the control program, it is important to take a few minutes to understand how the module processes and represents the analog signals.

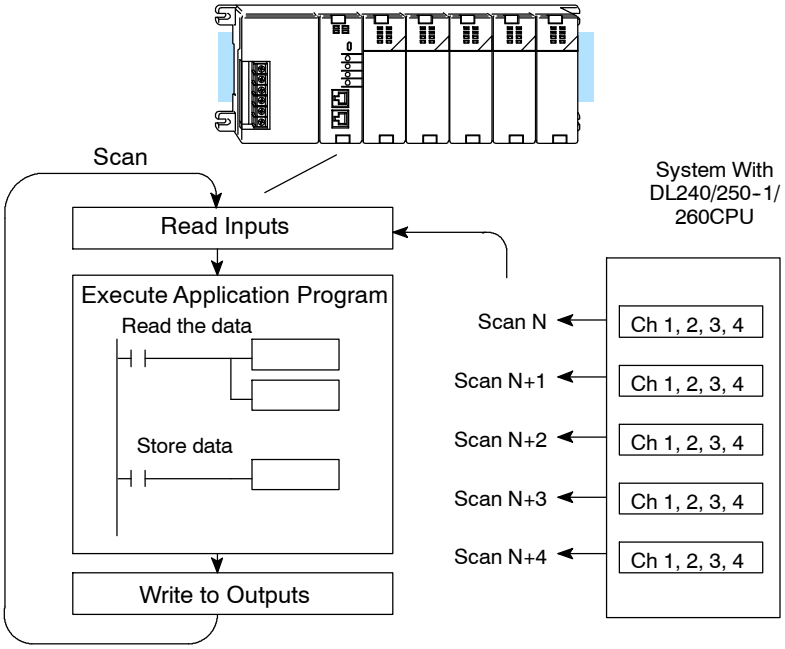
Channel Scanning Sequence for a DL230 CPU (Multiplexing)

The module can supply different amounts of data per scan, depending on the type of CPU you are using. The DL230 can obtain one channel of data per CPU scan. Since there are four channels, it can take up to four scans to get data for all channels. Once all channels have been scanned the process starts over with channel 1. Unused channels are not processed, so if you select only two channels, then each channel will be updated every other scan. The multiplexing method can also be used for the DL240/250-1/DL260 CPUs.



Channel Scanning Sequence with a DL240, DL250-1 or DL260 CPU (Pointer Method)

If you are using a DL240, DL250-1 or DL260 CPU, you can obtain all four channels of input data in one scan. This is because the DL240/250-1/260 CPU supports special V-memory locations that are used to manage the data transfer (this is discussed in more detail in the section on Writing the Control Program).



Analog Module Updates

Even though the channel updates to the CPU are synchronous with the CPU scan, the module asynchronously monitors the analog transmitter signal and converts the signal to a 12-bit binary representation. This enables the module to continuously provide accurate measurements without slowing down the discrete control logic in the RLL program.

For the vast majority of applications, the values are updated much faster than the signal changes. However, in some applications, the update time can be important. The module takes approximately 10 milliseconds to sense 95% of the change in the analog signal.

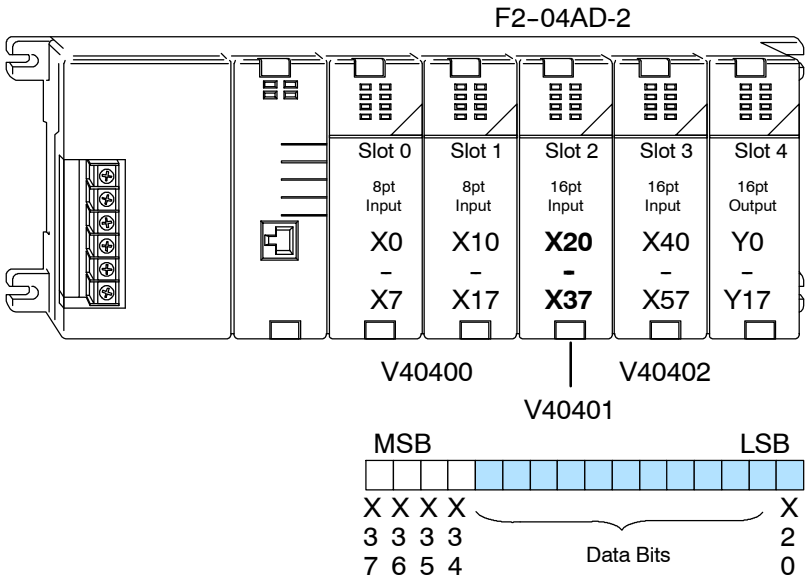
Note, this is *not* the amount of time required to convert the signal to a digital representation. The conversion to the digital representation takes only a few microseconds. Many manufacturers list the conversion time, but it is the settling time of the filter that really determines the update time.

Understanding the Input Assignments

You may recall that the module appears to the CPU as a 16-point discrete input module. You can use these points to obtain:

- an indication of which channel is active.
- the digital representation of the analog signal.
- module diagnostic information.

Since all input points are automatically mapped into V memory, it is very easy to determine the location of the data word that will be assigned to the module.

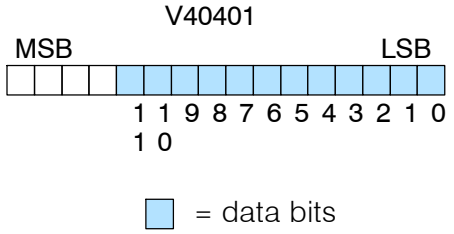


Within these word locations, the individual bits represent specific information about the analog signal.

Analog Data Bits

The first twelve bits represent the analog data in binary format.

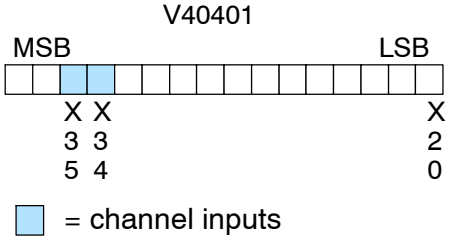
Bit	Value	Bit	Value
0	1	6	64
1	2	7	128
2	4	8	256
3	8	9	512
4	16	10	1024
5	32	11	2048



Active Channel Indicator Inputs

Two of the inputs are binary encoded to indicate the active channel (remember, the V-memory bits are mapped directly to discrete inputs). The inputs automatically turn on and off to indicate the current channel for each scan.

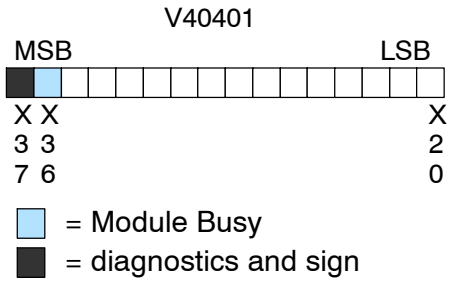
Scan	X35	X34	Channel
N	Off	Off	1
N+1	Off	On	2
N+2	On	Off	3
N+3	On	On	4
N+4	Off	Off	1



Module Diagnostic and Sign Inputs

The last two inputs are used for module diagnostics.

Module Busy — The first diagnostic input (X36 in this example) indicates a "busy" condition. This input will always be active on the first PLC scan, to tell the CPU that the analog data is not valid. After the first scan, the input usually only comes on when extreme environmental (electrical) noise problems are present.



The last input (X37 in this example) is used for two purposes.

Signal Sign — When using bipolar ranges you need to know if the value returned is positive or negative. When this input is off, the value stored represents a positive analog signal (0V or greater). If the input is on, then the value stored represents a negative input signal (less than 0V).

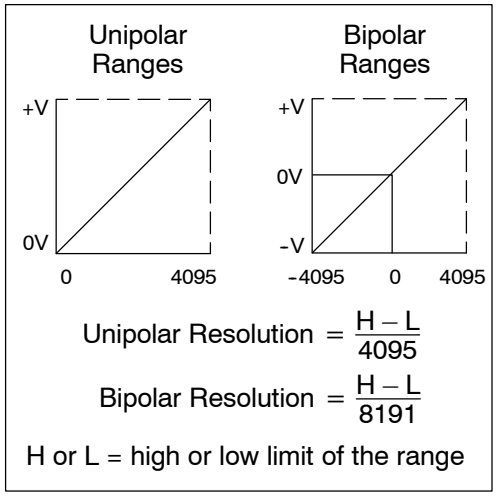
Channel Failure — This input can also indicate an analog channel failure. For example, if the 24 VDC input power is missing or the terminal block is loose, the module turns on this input and returns a data value of zero (remember, if this input is on and the data value is *not* equal to zero, then it is just showing the sign).

The next section, Writing the Control Program, shows how you can use these inputs in your control program.

Module Resolution

Since the module has 12-bit unipolar resolution, the analog signal is converted into 4096 counts ranging from 0 – 4095 (2^{12}). For example, with a 0 to 10V scale, a 0V signal would be 0 and a 10V signal would be 4095. This is equivalent to a binary value of 0000 0000 0000 to 1111 1111 1111, or 000 to FFF hexadecimal. The diagram shows how this relates to each signal range.

The bipolar ranges utilize a sign bit to provide 13-bit resolution. A value of 4095 can represent the upper limit of either side of the range. Use the sign bit to determine negative values.



Each count can also be expressed in terms of the signal level by using the equation shown. The following table shows the smallest detectable signal change that will result in one LSB change in the data value for each input signal range.

Range	Signal Span (H - L)	Divide By	Smallest Detectable Change
0 to +10V	10V	4095	2.44 mV
–10 to +10V	20V	8191	2.44 mV
0 to +5V	5V	4095	1.22 mV
–5V to +5V	10V	8191	1.22 mV

Writing the Control Program

Reading Values: Pointer Method and Multiplexing

There are two methods of reading values:

- The pointer method
- Multiplexing

You *must* use the multiplexing method when using a DL230 CPU. You must also use the multiplexing method with remote I/O modules (the pointer method will not work). You can use either method when using DL240, DL250-1 and DL260 CPUs, but for ease of programming it is strongly recommended that you use the pointer method.

Pointer Method

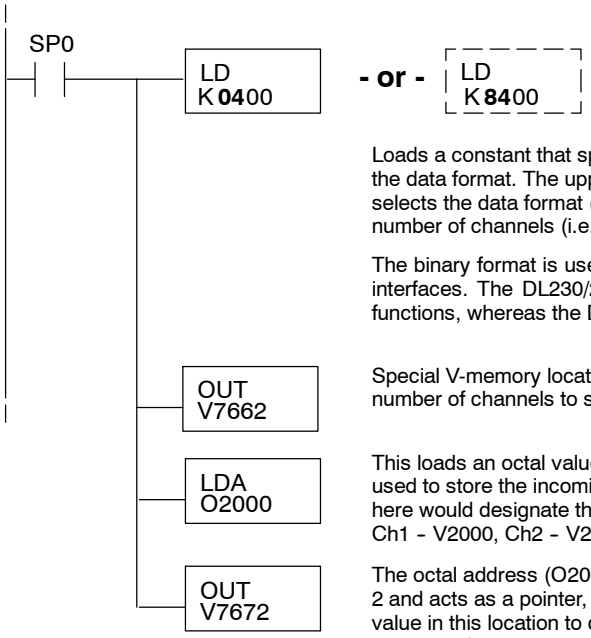
230	240	250-1	260
×	✓	✓	✓

DL240, DL250-1 and DL260 CPUs have special V-memory locations assigned to each base slot that greatly simplify the programming requirements. These V-memory locations:

- specify the data format
- specify the number of channels to scan
- specify the storage locations

NOTE: DL250 CPUs with firmware release version 1.06 or later support this method. If you must use the DL230 example, module placement in the base is very important. Review the section earlier in this chapter for guidelines.

The example program shows how to setup these locations. Place this rung anywhere in the ladder program or in the Initial Stage if you are using RLL*PLUS* instructions. This is all that is required to read the data into V-memory locations. Once the data is in V-memory, you can perform math on the data, compare the data against preset values, and so forth. V2000 is used in the example but you can use any user V-memory location. In this example the module is installed in slot 2. You should use the V-memory locations for your module placement. The pointer method automatically converts values to BCD.



Loads a constant that specifies the number of channels to scan and the data format. The upper byte, most significant nibble (MSN) selects the data format (i.e. 0=BCD, 8=Binary), the LSN selects the number of channels (i.e. 1, 2, 3, or 4).

The binary format is used for displaying data on some operator interfaces. The DL230/240 CPUs do not support binary math functions, whereas the DL250 does.

Special V-memory location assigned to slot 2 that contains the number of channels to scan.

This loads an octal value for the first V-memory location that will be used to store the incoming data. For example, the O2000 entered here would designate the following addresses.
Ch1 - V2000, Ch2 - V2001, Ch3 - V2002, Ch 4 - V2003

The octal address (O2000) is stored here. V7672 is assigned to slot 2 and acts as a pointer, which means the CPU will use the octal value in this location to determine exactly where to store the incoming data.

The tables below show the special V-memory locations used by the DL240, DL250–1 and DL260 for the CPU base and local expansion base I/O slots. Slot 0 (zero) is the module next to the CPU or D2–CM module. Slot 1 is the module two places from the CPU or D2–CM, and so on. Remember, the CPU only examines the pointer values at these locations after a mode transition. Also, if you use the DL230 (multiplexing) method, verify that these addresses in the CPU are zero.

The Table below applies to the DL240, DL250–1 and DL260 CPU base.

CPU Base: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V7660	V7661	V7662	V7663	V7664	V7665	V7666	V7667
Storage Pointer	V7670	V7671	V7672	V7673	V7674	V7675	V7676	V7677

The Table below applies to the DL250–1 or DL260 expansion base 1.

Expansion Base D2-CM #1: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36000	V36001	V36002	V36003	V36004	V36005	V36006	V36007
Storage Pointer	V36010	V36011	V36012	V36013	V36014	V36015	V36016	V36017

The Table below applies to the DL250–1 or DL260 expansion base 2.

Expansion Base D2-CM #2: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36100	V36101	V36102	V36103	V36104	V36105	V36106	V36107
Storage Pointer	V36110	V36111	V36112	V36113	V36114	V36115	V36116	V36117

The Table below applies to the DL260 CPU expansion base 3.

Expansion Base D2-CM #3: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36200	V36201	V36202	V36203	V36204	V36205	V36206	V36207
Storage Pointer	V36210	V36211	V36212	V36213	V36214	V36215	V36216	V36217

The Table below applies to the DL260 CPU expansion base 4.

Expansion Base D2-CM #4: Analog Input Module Slot-Dependent V-memory Locations								
Slot	0	1	2	3	4	5	6	7
No. of Channels	V36300	V36301	V36302	V36303	V36304	V36305	V36306	V36307
Storage Pointer	V36310	V36311	V36312	V36313	V36314	V36315	V36316	V36317

Using Bipolar Ranges (Pointer Method)

✗	✓	✓	✓
230	240	250-1	260

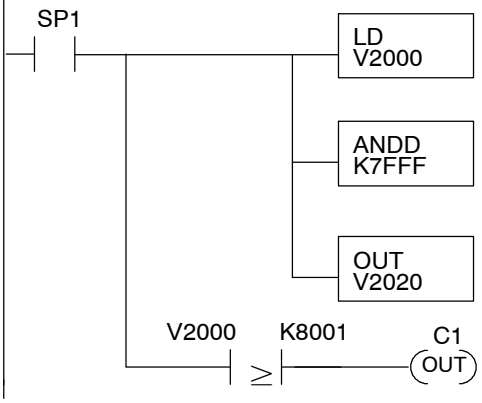
With bipolar ranges, you need some additional logic to determine whether the value being returned represents a positive voltage or a negative voltage. For example, you may need to know the direction for a motor. With the DL240/250 CPU, you *cannot* use the last input (X37 in the previous examples) to show the sign for each channel. This is because the DL240/250-1/260 reads all four channels in one scan. Therefore, if you tried to use X37 you would only be monitoring the last channel that was read. You would not be able to determine the sign for the previous three channels. There is a simple solution:

- If you get a value greater than or equal to 8001, the value is negative.

The sign bit is the most significant bit, which combines 8000 to the data value. If the value is greater than or equal to 8001, you only have to mask the most significant bit and the active channel bits to determine the actual data value.

The following program shows how you can accomplish this. Since you always want to know when a value is negative, these rungs should be placed *before* any other operations that use the data, such as math instructions, scaling operations, and so forth. Also, if you are using stage programming instructions, these rungs should be in a stage that is always active. Please note, you only need this logic for each channel that is using bipolar input signals. The example only shows two channels.

Check Channel 1



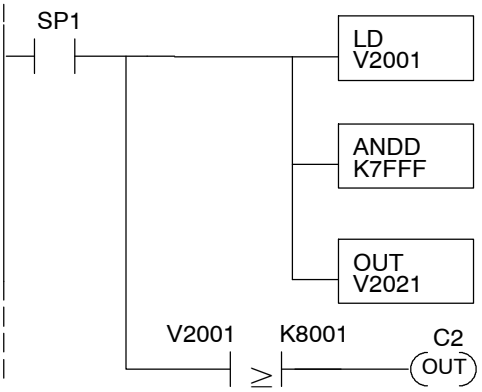
Load channel 1 data from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data if it is set. Without this step, negative values will not be correct, so do not forget to include it.

Put the actual signal value in V2020. Now you can use the data normally.

Channel 1 data is negative when C1 is on (a value of -1 reads as 8001, -2 is 8002, etc.).

Check Channel 2



Load channel 2 from V-memory into the accumulator. Remember, the data can be negative. Contact SP1 is always on.

This instruction masks the sign bit of the BCD data if it is set. Without this step, negative values will not be correct, so do not forget to include it.

Put the actual signal value in V2021. Now you can use the data normally.

Channel 2 data is negative when C2 is on (a value of -1 reads as 8001, -2 is 8002, etc.).

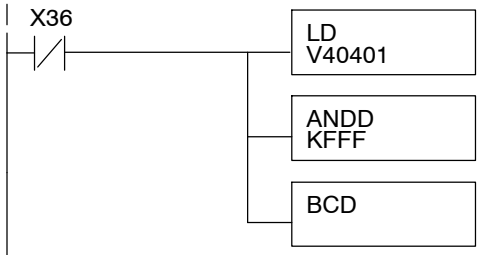
Reading Values (Multiplexing)

230	240	250-1	260
✓	✓	✓	✓

The DL230 CPU *does not* have the special V-memory locations that allow you to automatically enable the data transfer. Since all channels are multiplexed from a single data word, the control program must be setup to determine which channel is being read. Since the module appears as 16 X input points to the CPU, it is very easy to use the active channel status bits to determine which channel is being monitored.

Note, this example is for a module installed as shown in the previous examples. The addresses used would be different if the module was used in a different I/O configuration. You can place these rungs anywhere in the program, or if you are using stage programming place them in a stage that is always active.

Load data when module is not busy.

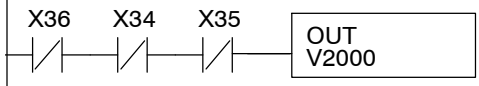


Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

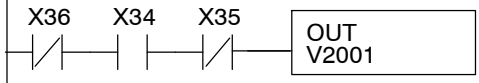
It is usually easier to perform math operations in BCD. So it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

Store Channel 1



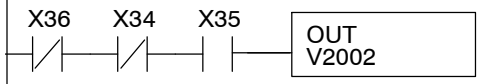
When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000.

Store Channel 2



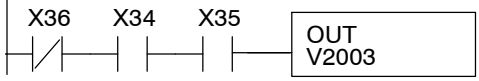
When X34 is on and X35 is off, channel 2 data is stored in V2001.

Store Channel 3



When X34 is off and X35 is on, channel 3 data is stored in V2002.

Store Channel 4

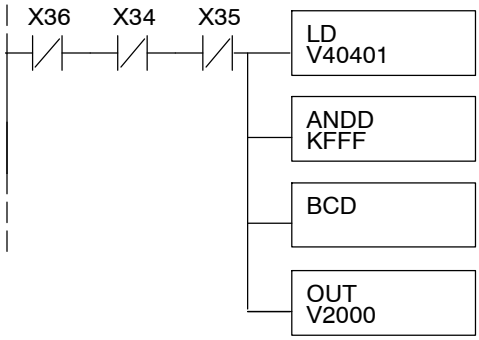


When both X34 and X35 are on, channel 4 data is stored in V2003.

Single Channel Selected

Since you do not have to determine which channel is selected, the single channel program is even simpler.

Store channel 1 when module is not busy.



Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

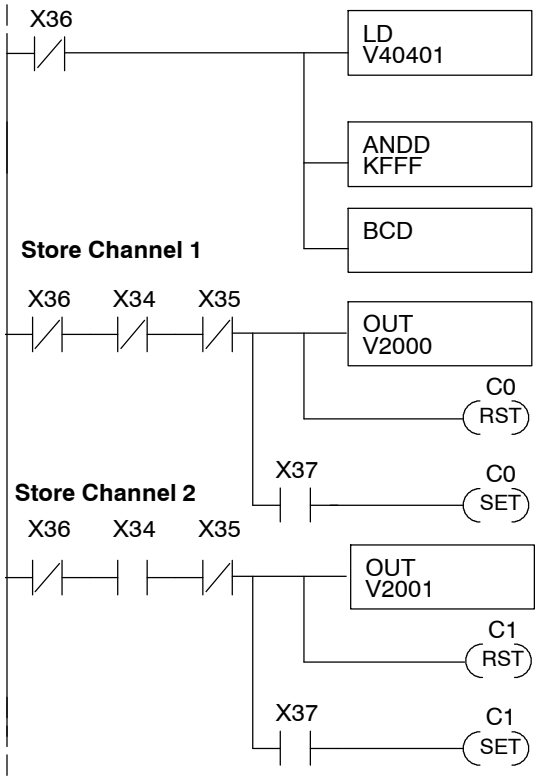
When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000.

Using Bipolar Ranges (Multiplexing)

With bipolar ranges, you need some additional logic because you need to know if the value being returned represents a positive voltage or a negative voltage. For example, you may need to know the direction for a motor. Since the DL230 only reads one channel per scan, you can use the last input (X37 in the examples) to show the sign.

The following program shows how you can accomplish this. Since you always want to know when a value is negative, these rungs should be placed *before* any operations that use the data, such as math instructions, scaling operations, and so forth. Also, if you are using stage programming instructions these rungs should be in a stage that is always active. Please note, you only need the additional logic for those channels that are using bipolar input signals. The example shows two channels but you can repeat these steps for all four channels if necessary.

Load data when module is not busy.



Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

It is usually easier to perform math operations in BCD, so it is best to convert the data to BCD immediately. You can leave out this instruction if your application does not require it.

When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000. C0 is reset to indicate channel one's value is positive.

If X37 is on, then the data value represents a negative voltage. C0 is set to indicate channel 1's value is negative.

When the module is not busy, and X34 is on and X35 is off, channel 2 data is stored in V2001. C1 is reset to indicate that channel 2's value is positive.

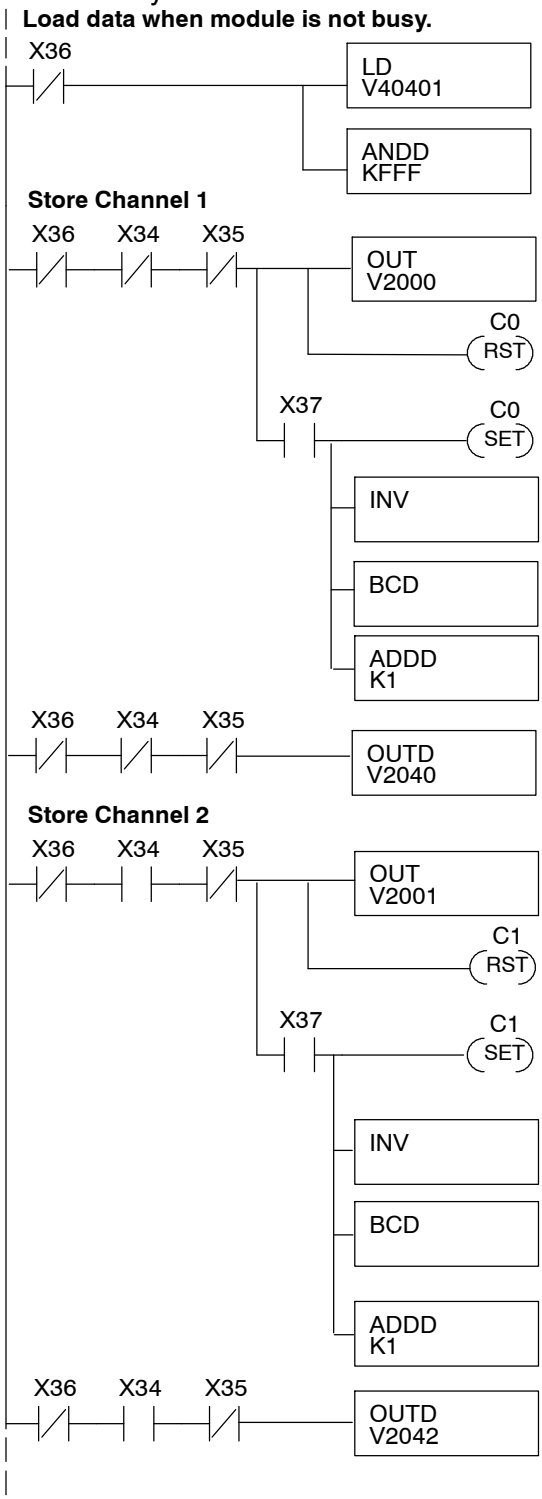
If X37 is on, then the data value represents a negative voltage. C1 is set to indicate that channel 2's value is negative.

Using 2's Complement (Multiplexing)

230	240	250-1	260
✓	✓	✓	✓

The 2's complement data format may be required to display negative values on some operator interface devices. It could also be used to simplify data averaging on bipolar signals.

The example shows two channels, but you can repeat these steps for all four channels if necessary.



Loads the complete data word into the accumulator. The V-memory location depends on the I/O configuration. See Appendix A for the memory map.

This instruction masks the channel identification bits. Without this, the values used will not be correct, so do not forget to include it.

When the module is not busy and X34 and X35 are off, channel 1 data is stored in V2000. C0 is reset to indicate that channel 1's value is positive.

If X37 is on, then the data value represents a negative voltage. C0 is set to indicate that channel 1's value is negative.

Invert the bit pattern in the accumulator.

Channel 1 data is in double word starting at V2040.

When the module is not busy and X34 is on and X35 is off, channel 2 data is stored in V2001. C1 is reset to indicate channel 2's value is positive.

If X37 is on, then the data value represents a negative voltage. C1 is set to indicate that channel 2's value is negative.

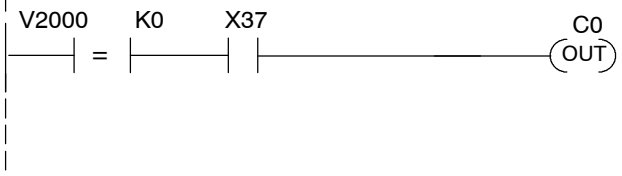
Invert the bit pattern in the accumulator.

Channel 2 data is in double word starting at V2042.

Analog Power Failure Detection

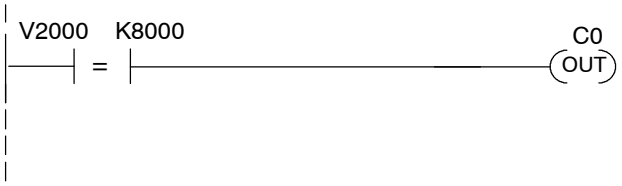
The analog module has a microcontroller that can diagnose analog input circuit problems. You can easily create a simple ladder rung to detect these problems. This rung shows an input point that would be assigned if the module was used as shown in the previous examples. A different point would be used if the module was installed in a different I/O configuration.

Multiplexing method



V-memory location V2000 holds channel 1 data. When a data value of zero is returned and input X37 is on, then the analog circuitry is not operating properly.

Pointers method



V-memory location V2000 holds channel 1 data. When a data value of 8000 is returned, then the analog circuitry is not operating properly.

Scaling the Input Data

Most applications usually require measurements in engineering units, which provide more meaningful data. This is accomplished by using the conversion formula shown.

You may have to make adjustments to the formula depending on the scale you choose for the engineering units.

$$\text{Units} = A \frac{H - L}{4095}$$

H = high limit of the engineering unit range

L = low limit of the engineering unit range

A = Analog value (0 - 4095)

For example, if you wanted to measure pressure (PSI) from 0.0 to 99.9 then you would have to multiply the analog value by 10 in order to imply a decimal place when you view the value with the programming software or a handheld programmer. Notice how the calculations differ when you use the multiplier.

Analog Value of 2024, slightly less than half scale, should yield 49.4 PSI

Example without multiplier

$$\text{Units} = A \frac{H - L}{4095}$$

$$\text{Units} = 2024 \frac{100 - 0}{4095}$$

$$\text{Units} = 49$$

Handheld Display

V 2001	V 2000
0000	0049

Example with multiplier

$$\text{Units} = 10\,A \frac{H - L}{4095}$$

$$\text{Units} = 20240 \frac{100 - 0}{4095}$$

$$\text{Units} = 494$$

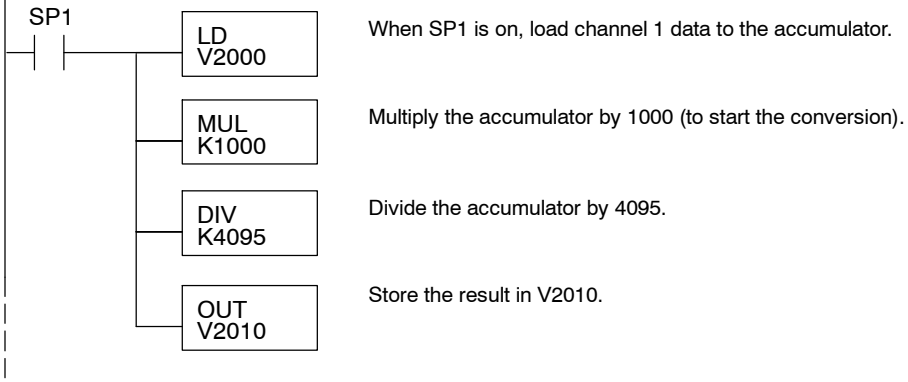
Handheld Display

V 2001	V 2000
0000	0494

This value is more accurate.

Here is how you would write the program to perform the engineering unit conversion. This example assumes you have BCD data loaded into the appropriate V-memory locations using instructions that apply for the model of CPU you are using.

NOTE: This example uses SP1, which is always on. You could also use an X, C, etc. permissive contact.



Analog and Digital Value Conversions

Sometimes it is useful to be able to quickly convert between the signal levels and the digital values. This is especially helpful during machine startup or troubleshooting. Remember, this module *does not* operate like other versions of analog input modules that you may be familiar with. The bipolar ranges use 0–4095 for both positive and negative voltages. The sign bit allows this, which actually provides better resolution than those modules that do not offer a sign bit. The following table provides formulas to make this conversion easier.

Range	If you know the digital value ...	If you know the signal level ...
0 to 5V –5V to +5V	$A = \frac{5D}{4095}$	$D = \frac{4095}{5}$ (A)
0 to 10V –10V to +10V	$A = \frac{-10D}{4095}$	$D = \frac{4095}{10}$ ABS(A)

For example, if you are using the –10 to +10V range and you have measured the signal at 6V, use the following formula to determine the digital value that is stored in the V-memory location that contains the data.

$$D = \frac{4095}{10} (A)$$

$$D = \frac{4095}{10} (6V)$$

$$D = (409.5)\ (6)$$

$$D = 2457$$

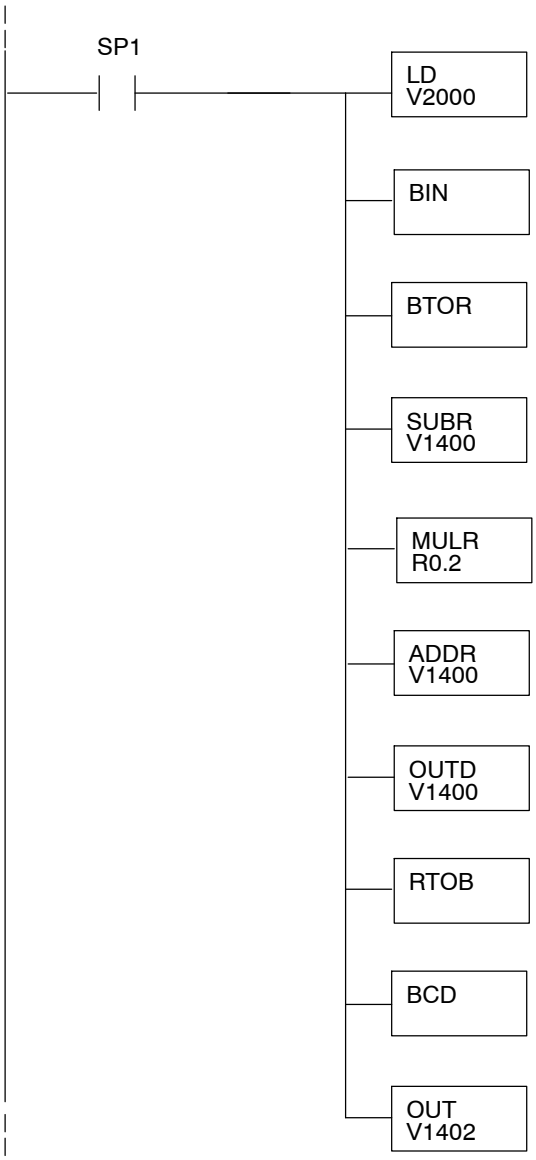
Filtering Input Noise (DL250-1, DL260 CPUs Only)

230	240	250-1	260
✗	✗	✓	✓

Add the following logic to filter and smooth analog input noise in DL250-1/DL260 CPUs. This is especially useful when using PID loops. Noise can be generated by the field device and/or induced by field wiring.

The analog value in BCD is first converted to a binary number because there is not a BCD-to-real conversion instruction. Memory location V1400 is the designated workspace in this example. The MULR instruction is the filter factor, which can be from 0.1 to 0.9. The example uses 0.2. A smaller filter factor increases filtering. You can use a higher precision value, but it is not generally needed. The filtered value is then converted back to binary and then to BCD. The filtered value is stored in location V1402 for use in your application or PID loop.

NOTE: Be careful not to do a multiple number conversion on a value. For example, if you are using the pointer method to get the analog value, it is in BCD and must be converted to binary. However, if you are using the conventional method of reading analog and are masking the first twelve bits, then it is already in binary and no conversion using the BIN instruction is needed.



Loads the analog signal, which is a BCD value and has been loaded from V-memory location V2000, into the accumulator. Contact SP1 is always on.

Converts the BCD value in the accumulator to binary. Remember, this instruction is not needed if the analog value is originally brought in as a binary number.

Converts the binary value in the accumulator to a real number.

Subtracts the real number stored in location V1400 from the real number in the accumulator, and stores the result in the accumulator. V1400 is the designated workspace in this example.

Multiplies the real number in the accumulator by 0.2 (the filter factor), and stores the result in the accumulator. This is the filtered value.

Adds the real number stored in location V1400 to the real number filtered value in the accumulator, and stores the result in the accumulator.

Copies the value in the accumulator to location V1400.

Converts the real number in the accumulator to a binary value, and stores the result in the accumulator.

Converts the binary value in the accumulator to a BCD number. **Note:** the BCD instruction is not needed for PID loop PV (loop PV is a binary number).

Loads the BCD number filtered value from the accumulator into location V1402 to use in your application or PID loop.